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ABSTRACT

The concept of shape often enters introductory cultural geography textbooks through the subject of political geography. This paper focuses on a quantitative way to introduce the concept of shape to students of cultural geography. The measure used in this approach was to compare the perimeter of the sovereign state with the perimeter of a circle having the same area as the state. Students, on noting both the quantitative shape index and the qualitative descriptions of outline and the shape traced from conformal maps, learn that shape is subject to the perceptions and interpretation of the individual geographer. They also learn that the importance of shape and compactness to national security and communications is dependent on available technology with the developmental stage of the country being considered. Following a short discussion of shape and its use in the theoretical political geography context, a review of shape measurement as used in the physical and social sciences is provided. The method for calculating an index of shape, with data and examples using sovereign states, is then provided. The paper closes with an example of an exercise that has been used successfully by students in introductory cultural geography classes designed for nonmajors. (PVD)

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INTRODUCING THE MEASUREMENT OF SHAPE IN FRESHMAN HUMAN GEOGRAPHY

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INTRODUCING THE MEASUREMENT OF SHAPE IN FRESHMAN HUMAN GEOGRAPHY

INTRODUCTION:

Geographers are concerned with spatial concepts and therefore the borders of identifiable cultural and physical features. Thus, geographers have directed their attention toward the identification of shape as defined by the boundary delimiting the area occupied by a feature.

The concept of shape often enters introductory cultural geography textbooks through the subject of political geography. Currently popular introductory books in cultural geography introduce shape as a series of definitions rather than in a quantitative manner. (de Blij, 1993; Fellmann, et al., 1995; Getis, et al., 1991; Jordan, et al., 1994; Rubenstein, 1996). This paper focuses on a quantitative way to introduce the concept of shape to the student of cultural geography. Following a short discussion of shape and its use in the theoretical political geography context, a review of the measurement of shape as used in the physical and social sciences is provided. A method, with data and examples using sovereign states, for calculating a index of shape, is then provided. The paper closes with an example of an exercise which has been successfully used by students in introductory cultural geography classes designed for non-majors.

CONCEPT OF SHAPE:

Shape, also termed 'morphology' and 'spatial form' by de Blij (1993) in the context of cultural geography, focuses on the projected surface outline of an area which is occupied by an identifiable cultural feature. These feature may be a characteristic of the population, the outline of a political unit, the area covered by a type of economic activity or physical property amongst others. In all cases it is apparent, when considering a single feature, that two features cannot dominate over a particular space simultaneously. It is therefore possible to outline the areas in which one feature is dominant . For example, a glance at any atlas will provide a number of maps showing the dominance, by area, of one activity or entity over the other. Goode's World Atlas (Espenshade, et al., 1990) indicates the distribution of religions, literacy, languages, life expectancy, predominant economies, calorie supply and a host of other variables of interest to the cultural geographer.

One of the cultural entities which essentially covers the solid surface of earth is that of political control, ownership or sovereignty. With very few exceptions, all portions of the earth's solid surface (and also a fair portion of the sea surface and sea bed) are claimed by a political state. A major exception is the Antarctic. Here, although seven countries make ownership claims, of which three overlap, there are no hostilities primarily due to remote location, harsh environment, the absence of a permanent population and international treaty. Additional examples of conflicting ownership claims are: (a) Kuril Islands in which Japan and Russia have had a continuing, but peaceful, dispute which has

forestalled their signing an agreement to terminate the Second World War (Blustein, 1993), and (b) the Spratly Islands which are the subject of an ongoing dispute between China, Vietnam and the Philippines.

In general each portion of the earth's land area is claimed by some sovereign state and, because two states cannot claim, occupy and effectively control the same piece of territory simultaneously there is an ample opportunity to introduce shape, as a feature of interest to geographers , through the study of the outlines of individual countries.

SHAPE IN THE INTRODUCTORY CULTURAL GEOGRAPHY CONTEXT:

Getis et al., (1991) in their chapter on Political Geography introduce shape by stating: "Like size, a country's shape can affect its well-being as a state by fostering or hindering effective organization." (p. 243). They comment that, absent any major physical barriers (e.g. mountains, deserts, rivers) which would restrict movement, the ideal shape, from the political point of view, would be a circle. Jordan et al., (1994) make essentially the same comment stating that

> "As a rule, the more compact a nation's territory, the more cohesive it is likely to be. Theoretically, the most desirable shape for a nation is circular or hexagonal. These two geometric forms maximize compactness, allow short communications lines within a country, and minimize the amount of border to be defended." (p. 141).

Shape is considered a statement of political security through the centralization of military and political power for maximum control, for should the state be shaped as a circle then all points of the state could be accessed with the minimum amount of effort from this centralized point. Also, because a circle has the maximum area contained within a given circumference, it follows that this shape is as compact as possible. Of course it is not possible to completely cover a surface with circles without either (a) having significant overlap (which, from the point of political control, sovereignty and peaceful coexistence, is not feasible) or (b) having some areas under no political control which is also generally not the case in the modern world.

The best shape, given the hypothetical featureless plane, would be to have the nation states shaped as hexagons. This allows the complete coverage of the surface with no overlap yet maintain a very compact shape.

However the world is not a featureless plain, as there are numerous physical barriers and constraints (e.g. mountain barriers, shorelines) as well as cultural barriers (results of historical occupancy, desire for putting culture groups together as a single unit, etc.) to having the states shaped as hexagons.

When such a discussion has been raised in the classroom, the students have quickly grasped the importance of the shape. However, difficulties arise with the introduction of the definition of shape.

DEFINITION OF SHAPE:

A number of terms are applied to the shapes of states. In introductory texts five qualitative terms are commonly used: compact, elongates, fragmented, perforated and prorupt (Table 1). Shape has not been quantified in any of these texts. Consequently, although the shape is well defined, it is not measured and this leads to a classroom discussion focusing on the 'boundaries' or limits which should be applied when deciding which term applies to which state. How irregular must a state be before it is no longer identified as ' compact'? What is the length versus width (absolute or relative) necessary for the state to be termed 'elongated"? Because many of the states are not contiguous there is little controversy concerning the use of the term fragmented, exclave and enclave and pene-enclave). Indeed, these terms are not, in a strict sense, a statement of shape but rather the identification of the contiguity of the state.

SHAPE IN A VARIETY OF CONTEXTS:

A number of efforts have been made to measure shapes of items, including grains of sands (Cox, 1927), rock particles (Wadel, 1932), urban and trade areas (Boyce and Clark, 1964), drainage basins (Gustafson, 1973; Chorley, et al.; 1957), electoral districts (Taylor, 1973; Neimi, 1990). and the shapes of entire nations (Pounds, 1963). The methods, involving a wide array of complexity, are often designed for specific applications. One method, that outlined in Pounds, is the most appropriate for use in the introductory classroom exercise focusing on quantifying the shapes of sovereign states, because the method lacks any arbitrary aspects (such as finding the geometric center of an irregular area).

Pounds (p. 46) makes the following comment:

> "Ideally, it has been claimed, a state should be circular in plan, though no state is or could be so regular in geometrical form. One can only say that states are compact or the reverse, that the only possible measure of this is the length of the boundary in relation to the area. Such a calculation presents difficulties and has not been made for more than a few states."

Pounds does not explain the nature of the 'difficulties'. However, given the time of the writing, three possibilities come to the fore:

a) The absence of detailed data on both the area and the perimeter of the several states;

b) The lack of an efficient method of calculation;

c) How contiguous, or connected, the state may be.

Today the first two difficulties have been overcome, for both the data and the accurate and mechanical calculation methods are available. The contiguousness of the state continues to be a problem and is one which remains as the weak link in such studies.

The data (area and boundary) are listed for each country, overseas department, territory and dependency, in the 'geography' section of the World Fact Book (CIA, 1995). Typically two types of area (total area and land area) and two types of boundaries (sea boundaries or coastline and land boundaries) are listed for the several countries. The boundary data also identifies the length of the boundary with each of the neighboring country.

This source is a valuable asset for any introductory cultural geography course because:

a) it is updated annually to include political changes (such as the recent breakup of the USSR and Yugoslavia)

b) it is easily available from any U.S. Government Book Store and nearly all libraries;

c) the price is reasonable (the annual editions continue to be $US29.00);

d) the data are provided for all sovereign states using a consistent format.

Unfortunately this data source does not identify the method by which the perimeters of the states were determined. Different methods (measurement from maps of varying scales and accuracy, actual surveys, aerial photography or derivation from satellite imagery) can lead to widely varying data.

Typically, in my courses in introductory human geography, I provide the students with a set of data sheets extracted from this source. We refer to these data sheets throughout the two semester sequence in cultural geography.

For those institutions having access to a Geographic Information System, such as ArcView, the required data for a number of different cultural constructs (such as states, counties of the United States) may be readily available. The entire exercise can be completed using those data and programs.

MEASUREMENT OF SHAPE:

Pounds (1963) does not provide the formulae used to determine the shape of a country and provides guidance through his footnote to Table 3. (Reproduced here as Table 2). Using Pound's method we need only two formulae from elementary geometry:

$$A = \Pi r^2 \quad (1)$$

$$C = 2\Pi r \quad (2)$$

in which: A is the area is the area of a circle.
C is the circumference of a circle.
Π is the constant (3.1416).

We need to make a minor modification for this work, in that the 'circumference' of the state is given as the sum of two measurements. Thus:

$$P = S + L \qquad (3)$$

In which: P is the total perimeter of the state (in km).
S is the total sea boundary (in km).
L is the total land boundary (in km).

To determine the shape index of the sovereign state, the student proceeds as follows:

STEP 1. Determine the radius of a circle having the same area as the state using equation (1):

$$A = \Pi r^2$$

thus:

$$\sqrt{A/\Pi} = r$$

in which:

A is the area of the state from the World Fact Book (in sq. km.).
r is the calculated radius of a circle having area (A) (in km.).

STEP 2. Determine the circumference of a hypothetical circle having the same radius as the hypothetical circle from Step 1.

$$C_h = 2\Pi r \qquad (4)$$

in which:

C_h is the circumference of a hypothetical circle having radius r
r is the calculated radius of a circle having area (A) (from step 1) (in km.).

STEP 3. Determine the total perimeter around the country using equation (3):

$$P = S + L$$

STEP 4. Determine the shape index of the state by comparing the hypothetical circumference to the length of the actual boundaries, using equation (5):

$$\text{Shape Index} = (P / C_h) \times 100 \qquad (5)$$

in which:

C_h is the circumference of a hypothetical circle (from step 2);
P is the total distance (perimeter) around the country (from step 3).

AN EXAMPLE:

URUGUAY:	CHILE
A = 173,620 sq. km	A= 748,800 sq. km.
P = 660 km + 1,564 km = 2224 km.	P = 6,435 km + 6,171 km = 12,606 km.

STEP 1: DETERMINE THE RADIUS OF A CIRCLE HAVING SAME AREA AS THE STATE.

URUGUAY	CHILE
$A = \prod r^2$	$A = \prod r^2$
$176{,}220 \text{ km} = 3.1416 \times r^2$	$756{,}950 \text{ km} = 3.1416 \times r^2$
$176{,}220 \text{ km} / 3.1416 = r^2$	$756{,}950 \text{ km} / 3.1416 = r^2$
$56{,}092.44 \text{ km} = r^2$	$240{,}944.10 \text{ km} = r^2$
$\sqrt{56092.44}\text{km} = r$	$\sqrt{240940.10}\text{km} = r$
236.84 km = r	490.86 km = r

STEP 2: DETERMINE THE CIRCUMFERENCE OF A CIRCLE HAVING THE SAME RADIUS AS DETERMINED IN STEP 1.

URUGUAY	CHILE
$C_h = 2\prod r$	$C_h = 2\prod r$
$C_h = 2 \times 3.1416 \times 236.84$ km	$C_h = 2 \times 3.1416 \times 490.86$ km
$C_h = 1{,}488.10$ km	$C_h = 3084.18$ km

STEP 3: DETERMINE THE ACTUAL PERIMETER AROUND THE COUNTRY.

URUGUAY	CHILE
P = Sea + Land Boundary	P = Sea + Land Boundary
P = 660 km +1,564 km = 2,224 km	P = 6,435 km + 6,171 km = 12,606 km.

STEP 4: DETERMINE SHAPE INDEX BY COMPARING HYPOTHETICAL CIRCUMFERENCE TO ACTUAL PERIMETER

URUGUAY	CHILE
Shape Index = $(P / C_h) \times 100$	Shape Index = $(P / C_h) \times 100$
Shape Index = (2,224 km /1,488.10 km)x100	Shape Index = (12,606 km /3,084.18 km)x 100
Shape index = 149.45	Shape Index = 408.73

THE CALCULATED SHAPES OF SOVEREIGN STATES:

Table 3 presents the initial data, the calculated interim steps and the final shape index of 193 separate states listed in the 1994 edition of the CIA Fact Book. Data in the several columns are defined as follows:

AREA	The total area of the state in sq. km.
COAST	The total length of coastlines, in km.
LAND	The total length of land boundaries, in km.
TPER	The total perimeter (distance) around the state in kilometers. The sum of 'COAST' + 'LAND'.
RAD	The calculated radius of a circle having the same area as the true area of the state in km.
CIRCU	The circumference of a circle having the same area as the true area of the state in km.
INDEX	The ratio of the perimeter of the state to the hypothetical calculated circumference of the state.

Table 4 provides only the calculated shape index of the several states in ascending order. Note that Swaziland is the most compact with an index of 114.54 (Remember a perfect circle would have a shape index of 100.00) and the Micronesia Federated States, a highly fragmented insular state, is the least compact with an index of 6507.43.

DISCUSSION:

This approach to introduce the concept of shape has both advantages and pitfalls. The data are easily available and the calculation is straight forward and easily handled by students with basic mathematics skills. In addition it is quantitative. The main problem centers on the artificiality of the measurement where it is applied to states which are fragmented or perforated because the basic assumption of the method is that each state is continuous and contiguous. Thus, for states which have a high degree of fragmentation (such as the Philippines, with an index of 1869.00, Indonesia (1167.07), Japan (1365.25) and even Canada (2256.79) (all of which have numerous islands) the use of this quantitative approach introduces a high degree of artificiality to the concept of shape. Most students have been well aware of the 'fragmentation' of Indonesia and the Philippines as these states are amongst the most commonly used examples. Norway, a common example of an 'elongated' state is shown here to not only have a non-compact shape, but to also rank with Japan and Indonesia with respect to the shape index. One method to remove this problem introduced by the islands and highly irregular shorelines, would be to use the perimeter as defined by the territorial sea or the Extended Economic Zone. In such a

situation the insular states (e.g. Indonesia, the Micronesia Federated States, Canada) may be quite compact as the irregularities would have been subdued. Conversely, Belgium, a state noted for being 'compact' has an shape index of 234.01 which puts it in the rank with Sweden, Venezuela, Peru and Fiji.

In using this approach to introduce shape, it is stressed that this quantitative method is but one of several which may be used to evaluate the shapes of states. At the end of each exercise of calculating the shapes of 20 states selected by each student, the students are provided with conformal maps and asked to trace outlines of four states which represent the range from the most compact to the least compact as indicated by the shape index. When comparing their quantitative results with the traced outlines it immediately becomes apparent that the calculated states are not that closely related to the qualitative descriptions used to introduce the concept. Further, rather than simply accepting the statement that compactness is a (potential) surrogate for security, the students begin to recognize that absolute and relative location, topography, ease of access, resources and other features are also of great importance in determining the security and importance of the state in world affairs. They then begin to reevaluate MacKinder and the Heartland Theory in political geography not only from the point of view of shape, location and isolation but also from the perspective of modern warfare and the potential for the use of ICBM and satellite technology. Students recognize that although the 'Cold War' is over, the reality of 'Operation Desert Storm' in the Persian Gulf has emphasized that no country is 'isolated' from any other with respect to physical security. In a similar manner, when we consider shape and compactness as a surrogate for communications within a country, the use of telecommunication systems, both land and satellite links, emphasize that no portion of a country is permanently isolated from any other part as these communication devices spread throughout the developed and developing world. Although the analysis of shape is an old technique in geographic analysis and its execution has been computerized, it remains an important geographic concept. Still, using this basis and non-sophisticated approach for introducing the concept remains valid. The exercise in quantifying shape and the ensuing discussion usually terminates with a realization that as the changes in technology continue, some aspects of traditional concepts in political geography are also changing and that indeed, geography is a dynamic discipline which responds to the changing cultural environment.

CONCLUSION:

The concept of shape has generally been presented to introductory cultural geography classes from the perspective of state security and the ease of internal communications. This introduction has focused on the use of quantitative information and definitions. Supplementing the qualitative approach to shape with the quantitative measure emphasizes the difficulty of expressing shapes of geographic areas such as sovereign territory. The measure used in this approach has been to compare the perimeter of the sovereign state with the perimeter of a circle having the same area as the state. The measure is easily calculated using data which are readily available. The students, on noting both the quantitative

shape index and the qualitative descriptions of outline and the shape traced from conformal maps, note the poor correspondence between qualitative and quantitative approaches. This leads to a realization that shape, as in many of the variables considered in cultural geography, is subject to the perceptions and interpretation of the individual geographer. It is also quickly realized that the importance of shape and compactness is, from the point of view of security and communications, dependent on the available technology and the stage of development of the country being considered. This approach leads to and improved understanding of the importance of several aspects of human culture and provides but one of many insights to the realization that geography is a dynamic discipline.

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TABLE 1. TERMS, DEFINITIONS AND EXAMPLES OF SHAPES FOR SOVEREIGN STATES

SHAPE TERM	DEFINITION	EXAMPLE (source)
Compact	A state whose territory is nearly circular.(1) Distance from center to any boundary does not vary significantly (4)	Brazil (2); Belgium(3); Bulgaria (4); Cambodia (3); France (2); Kenya(3); Hungary (3); Poland (1, 4, 5); Uruguay (1, 3, 5); Zimbabwe (5)
Elongated	A state whose territory is long and narrow (1) (also termed 'attenuated' by (3)	Chile (1, 2, 3); Italy (3); Malawi (3); Norway (1, 2, 3); Panama (3); Togo (3); Vietnam (3)
Fragmented	A state whose territory contains isolated parts, separated and discontinuous.(1) deBlij identifies three different types of fragmentation:	Indonesia (1) Philippines (1)
	a) National territory entire of islands	Indonesia (4,5);Japan (4) New Zealand (4) Philippines(4,5)
	b) Continental landmass and islands	Italy (5); Malaysia, (5) ;Panama (4)
	c) Primarily on continents but separated by territory of another state	Angola (4); India (4) Russia (4);US (Alaska)
	Rubenstein identifies two types of fragmentation a) those separated by water b) those separated by intervening state.	
Enclave	A territory that is surrounded by but is not part of a state.(1)	San Marino/Italy (1) Vatican City/Italy (1) Lesotho/Rep.S. Af. (1&2)
Exclave	A portion of a state that is separated from the main territory and surrounded by another country.(1)	Kleinwalsertal/Austria (1) Baarle-Hertog/Belgium (1); Llivia/Spain (1) Cabinda/Angola (1); Melilla/Spain (1) Ceuta/Spain (1); Alaska/United States (2) Pakistan (until 1973) (2)
Pene-enclave	An intrusive piece of territory with only the smallest of outlets free of the surrounding state. (2)	The Gambia/Senegal (2)
Perforated	A state whose territory is interrupted ("perforated") by a separate, independent state totally contained within its borders.(1) A state that completely surrounds another state (4)	South Africa (Lesotho) (1, 3,4,5) Italy (San Marino) (3, 5)
Prorupt	A state of basically compact form that has one or more narrow extensions of territory.(1) (Also termed 'extended' by (3)) An otherwise compact state with large projecting extension (4)	Afghanistan (1, 4,5);Myanmar (1; 5); Namibia (1, 4,5,); Thailand (1, 3, 5); Zaire (1, 4,5)

SOURCES: (1) Getis, et al. ,1991; (2) Jordan et al., 1994; (3) de Blij (1993); (4) Rubenstein,(1996); (5) Fellmann et al. ,(1995)

TABLE 2. INDEX OF COMPACTNESS OF STATES
(FROM POUNDS, 1963. TABLE 3, p. 46)

STATE	LENGTH OF BOUNDARY AS PERCENTAGE OF THE MINIMUM BOUNDARY[1]
Uruguay	105
Rumania	137
Hungary	146
Switzerland	164
Belgium	167
Mexico	258
Chile	310

[1] Calculated by taking the length of boundary as a percentage of the shortest boundary (i.e. a circle) which could enclose the areas of the state.

TABLE 3 - CALCULATED SHAPE INDICES OF THE SOVEREIGN STATES.							
STATE NAME	AREA	COAST	LAND	T.PER	RAD.RAD.	CIRCU.	INDEX
AFGHANISTAN	647,500	0	5,529	5,529	453.99	2852.50	193.83
ALBANIA	28,750	362	720	1,082	95.66	601.07	180.01
ALGERIA	2,381,740	998	6,343	7,341	870.71	5470.82	134.18
ANDORRA	450	0	125	125	11.97	75.20	166.23
ANGOLA	1,246,700	1,600	5,198	6,798	629.95	3958.10	171.75
ANTIGUA&BARBUDA	440	153	0	153	11.83	74.36	205.76
ARGENTINA	2,766,890	4,989	9,665	14,654	938.47	5896.60	248.52
ARMENIA	29,800	0	1,254	1,254	97.39	611.95	204.92
AUSTRALIA	7,686,850	25,760	0	25,760	1564.22	9828.33	262.10
AUSTRIA	83,850	0	2,496	2,496	163.37	1026.50	243.16
AZERBAIJAN	86,600	0	2,013	2,013	166.03	1043.19	192.97
BAHAMAS, THE	13,940	3,542	0	3,542	66.61	418.54	846.28
BAHRAIN	620	161	620	781	14.05	88.27	884.81
BANGLADESH	144,000	580	4,246	4,826	214.09	1345.20	358.76
BARBADOS	430	97	0	97	11.70	73.51	131.96
BELARUS	207,600	0	3,098	3,098	257.06	1615.17	191.81
BELGIUM	30,510	64	1,385	1,449	98.55	619.19	234.01
BELIZE	22,960	386	516	902	85.49	537.14	167.92
BENIN	112,620	121	1,989	2,110	189.34	1189.63	177.37
BHUTAN	47,000	0	1,075	1,075	122.31	768.52	139.88
BOLIVIA	1,098,580	0	6,743	6,743	591.34	3715.53	181.48
BOSNIA&HERZEGOVINA	51,233	20	1,459	1,479	127.70	802.38	184.33
BOTSWANA	600,370	0	4,013	4,013	437.15	2746.72	146.10
BRAZIL	8,511,965	7,491	14,691	22,182	1646.04	10342.38	214.48
BRUNEI	5,770	161	381	542	42.86	269.27	201.28
BULGARIA	110,910	354	1,808	2,162	187.89	1180.57	183.13
BURKINA FASO	274,200	0	3,192	3,192	295.43	1856.26	171.96
BURMA(MYANMAR)	678,500	1,930	5,876	7,806	464.73	2919.98	267.33
BURUNDI	27,830	0	974	974	94.12	591.37	164.70
CAMBODIA	181,040	443	2,572	3,015	240.06	1508.32	199.89
CAMEROON	475,440	402	4,591	4,993	389.02	2444.29	204.27
CANADA	9,976,140	243,791	8,893	252,684	1781.99	11196.61	2256.79
CAPE VERDE	4,030	965	0	965	35.82	225.04	428.81
CENT.AF.REP.	622,980	0	5,203	5,203	445.31	2797.97	185.96
CHAD	1,284,000	0	5,968	5,968	639.30	4016.87	148.57
CHILE	756,950	6,435	6,171	12,606	490.86	3084.18	408.73
CHINA	9,596,960	14,500	22,143	36,643	1747.80	10981.77	333.67
COLUMBIA	1,138,910	3,208	7,408	10,616	602.10	3783.12	280.61
COMOROS	2,170	340	0	340	26.28	165.13	205.89
CONGO	342,000	169	5,504	5,673	329.94	2073.09	273.65
COSTA RICA	51,100	1,290	639	1,929	127.54	801.34	240.72
COTE D'IVOIRE	326,460	515	3,110	3,625	322.36	2025.44	178.97
CUBA	110,860	3,735	29	3,764	187.85	1180.30	318.90
CROATIA	56,538	5,790	2,028	7,818	134.15	842.90	927.51
CYPRUS	9,250	648	0	648	54.26	340.94	190.06
CZECH REPUBLIC	78,703	0	1,880	1,880	158.28	994.49	189.04
DENMARK	43,070	3,379	68	3,447	117.09	735.69	468.54
DJIBOUTI	22,000	314	508	822	83.68	525.80	156.33
DOMINICA	750	148	0	148	15.45	97.08	152.45
DOMINICAN REP.	48,730	1,288	275	1,563	124.54	782.53	199.74
ECUADOR	283,560	2,237	2,010	4,247	300.43	1887.68	224.99
EGYPT	1,001,450	2,450	2,689	5,139	564.60	3547.48	144.86
EL SALVADOR	21,040	307	545	852	81.84	514.20	165.70
EQUATORIAL GUINEA	28,050	296	539	835	94.49	593.71	140.64
ERITREA	121,320	1,151	1,630	2,781	196.51	1234.73	225.23
ESTONIA	45,100	1,393	557	1,950	119.82	752.82	259.02
ETHIPOIA	127,127	0	5,311	5,311	201.16	1263.93	420.20
FIJI	18,270	1,129	0	1,129	76.26	479.15	235.62
FINLAND	337,030	1,126	2,578	3,704	327.54	2057.97	179.98
FRANCE	547,030	3,427	2,892	6,319	417.28	2621.87	241.01
FR. GUIANA	91,000	378	1,183	1,561	170.19	1069.37	145.97
GABON	267,670	885	2,551	3,436	291.89	1834.03	187.35
GAMBIA, THE	11,300	80	740	820	59.97	376.83	217.61
GEORGIA	69,700	310	1,461	1,771	148.95	935.88	189.23
GERMANY	356,910	2,389	3,621	6,010	337.06	2117.80	283.79
GHANA	238,540	539	2,093	2,632	275.55	1731.35	152.02
GREECE	131,940	13,676	1,210	14,886	204.93	1287.64	1156.07
GRENADA	340	121	0	121	10.40	65.36	185.11

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TABLE 3

GUATEMALA	108,890	400	1,687	2,087	186.17	1169.77	178.41
GUINEA	245,860	320	3,399	3,719	279.75	1757.72	211.58
GUINEA-BISSAU	36,120	350	724	1,074	107.23	673.72	159.41
GUYANA	214,970	459	2,462	2,921	261.59	1643.59	177.72
HAITI	27,750	1,771	275	2,046	93.98	590.52	346.47
HONDURAS	112,090	820	1,520	2,340	188.89	1186.83	197.16
HUNGARY	93,030	0	1,989	1,989	172.08	1081.23	183.96
ICELAND	103,000	4,988	0	4,988	181.07	1137.69	438.43
INDIA	3,287,590	7,000	14,103	21,103	1022.97	6427.53	328.32
INDONESIA	1,919,440	54,716	2,602	57,318	781.65	4911.26	1167.07
IRAN	1,648,000	2,440	5,440	7,880	724.27	4550.76	173.16
IRAQ	437,072	58	3,631	3,689	372.99	2343.59	157.41
IRELAND	70,280	1,448	360	1,808	149.57	939.77	192.39
ISRAEL	20,770	273	1,006	1,279	81.31	510.89	250.35
ITALY	301,230	4,996	1,899	6,895	309.65	1945.60	354.40
JAMAICA	10,990	1,022	0	1,022	59.15	371.62	275.01
JAPAN	377,835	29,751	0	29,751	346.80	2179.00	1365.35
JORDAN	89,213	26	1,619	1,645	168.52	1058.81	155.36
KAZAKHSTAN	2,717,300	0	12,012	12,012	930.02	5843.52	205.56
KENYA	582,650	536	3,446	3,982	430.65	2705.88	147.16
KIRIBATI	717	1,143	0	1,143	15.11	94.92	1204.15
KOREA (NORTH)	120,540	2,495	1,673	4,168	195.88	1230.75	338.65
KOREA (SOUTH)	98,480	2,413	238	2,651	177.05	1112.45	238.30
KUWAIT	17,820	499	464	963	75.31	473.22	203.50
KYRGYZSTAN	198,500	0	3,878	3,878	251.37	1579.38	245.54
LAOS	236,800	0	5,083	5,083	274.55	1725.03	294.66
LATVIA	64,100	531	1,078	1,609	142.84	897.50	179.28
LEBANON	10,400	225	454	679	57.54	361.51	187.82
LESOTHO	30,350	0	909	909	98.29	617.57	147.19
LIBERIA	111,370	579	1,585	2,164	188.28	1183.01	182.92
LIBYA	1,759,540	1,770	4,383	6,153	748.38	4702.24	130.85
LIECHTENSTEIN	160	0	78	78	7.14	44.84	173.95
LITHUANIA	65,200	108	1,273	1,381	144.06	905.17	152.57
LUXEMBOURG	2,586	0	359	359	28.69	180.27	199.15
MACEDONIA	25,333	0	748	748	89.80	564.22	132.57
MADAGASCAR	587,040	4,828	0	4,828	432.27	2716.06	177.76
MALAWI	118,480	0	2,881	2,881	194.20	1220.19	236.11
MALAYSIA	329,750	4,675	2,669	7,344	323.98	2035.63	360.77
MALDIVES	300	644	0	644	9.77	61.40	1048.87
MALI	1,240,000	0	7,243	7,243	628.25	3947.45	183.49
MALTA	320	140	0	140	10.09	63.41	220.77
MARSHALL ISLANDS	181	370	0	370	7.59	47.69	775.81
MAURITANIA	1,030,700	754	5,074	5,828	572.78	3598.91	161.94
MAURITIUS	1,860	177	0	177	24.33	152.88	115.77
MEXICO	1,972,550	9,330	4,538	13,868	792.39	4978.74	278.54
MICRONESIA FED. ST.	702	6,112	0	6,112	14.95	93.92	6507.43
MOLDOVA	33,700	0	1,389	1,389	103.57	650.76	213.44
MONACO	1.9	4.1	4.4	9	0.78	4.89	173.95
MONGOLIA	1,565,000	0	8,114	8,114	705.80	4434.68	182.97
MOROCCO	446,550	1,835	2,002	3,837	377.02	2368.87	161.98
MOZAMBIQUE	801,590	2,470	4,571	7,041	505.13	3173.81	221.85
NAMIBIA	825,418	1,572	3,824	5,396	512.58	3220.64	167.54
NAURU	21	30	0	30	2.59	16.24	184.67
NEPAL	140,800	0	2,926	2,926	211.70	1330.17	219.97
NETHERLANDS	37,300	451	1,027	1,478	108.96	684.64	215.88
NEW ZEALAND	268,680	15,134	0	15,134	292.44	1837.48	823.63
NICARAGUA	129,494	910	1,231	2,141	203.02	1275.65	167.84
NIGER	1,267,000	0	5,697	5,697	635.06	3990.19	142.78
NIGERIA	923,700	853	4,047	4,900	542.24	3406.99	143.82
NORWAY	324,220	21,925	2,515	24,440	321.25	2018.48	1210.81
OMAN	212,460	2,092	1,374	3,466	260.05	1633.97	212.12
PAKISTAN	803,940	1,046	6,774	7,820	505.87	3178.46	246.03
PANAMA	78,200	2,490	555	3,045	157.77	991.31	307.17
PAPUA NEW GUINEA	461,690	5,152	820	5,972	383.35	2408.69	247.94
PARAGUAY	406,750	0	3,920	3,920	359.82	2260.84	173.39
PERU	1,285,220	2,414	6,940	9,354	639.61	4018.78	232.76
PHILIPPINES	300,000	36,289	0	36,289	309.02	1941.63	1869.00
POLAND	312,680	491	3,114	3,605	315.48	1982.24	181.87
PORTUGAL	92,080	1,793	1,214	3,007	171.20	1075.69	279.54
QATAR	11,000	563	60	623	59.17	371.79	167.57
ROMANIA	237,500	225	2,508	2,733	274.95	1727.58	158.20
RUSSIA	17,075,200	37,653	20,139	57,792	2331.35	14648.34	394.53

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RWANDA	26,340	0	893	893	91.57	575.33	155.22
ST.KITTS & NEVIS	269	135	0	135	9.25	58.14	232.19
ST. LUCIA	620	158	0	158	14.05	88.27	179.00
ST.VINC/GRENAD.	340	84	0	84	10.40	65.36	128.51
SAN MARINO	60	0	39	39	4.37	27.46	142.03
SAO TOME AND PRINCIPE	960	209	0	209	17.48	109.84	190.29
SAUDI ARABIA	1,960,582	2,640	4,415	7,055	789.98	4963.61	142.13
SENEGAL	196,190	531	2,640	3,171	249.90	1570.16	201.95
SERBIA & MONTENEGRO	102,350	199	2,246	2,445	180.50	1134.09	215.59
SEYCHELLES	455	491	0	491	12.03	75.62	649.34
SIERRA LEONE	71,740	402	958	1,360	151.11	949.48	143.24
SINGAPORE	632	193	0	193	14.18	89.12	216.57
SLOVAKIA	48,845	0	1,355	1,355	124.69	783.46	172.95
SLOVENIA	20,296	32	1,045	1,077	80.38	505.02	213.26
SOLOMON IS.	26,450	5,313	0	5,313	91.76	576.53	921.56
SOMALIA	637,660	3,025	2,366	5,391	450.53	2830.74	190.44
SOUTH AFRICA	1,219,912	2,798	4,750	7,548	623.14	3915.34	192.78
SPAIN	504,750	4,964	1,903	6,867	400.83	2518.51	272.66
SRI LANKA	65,610	1,340	0	1,340	144.51	908.01	147.58
SUDAN	2,505,810	853	7,687	8,540	893.10	5611.51	152.19
SUIRNAME	163,270	386	1,707	2,093	227.97	1432.38	146.12
SWAZILAND	17,360	0	535	535	74.34	467.07	114.54
SWEDEN	449,964	3,218	2,205	5,423	378.45	2377.90	228.06
SWITZERLAND	41,290	0	1,852	1,852	114.64	720.32	257.11
SYRIA	185,180	193	2,253	2,446	242.78	1525.47	160.34
TAIWAN	35,980	1,448	0	1,448	107.02	672.41	215.34
TAJIKISTAN	143,100	0	3,651	3,651	213.42	1340.99	272.26
TANZANIA	945,090	1,424	3,402	4,826	548.48	3446.21	140.04
THAILAND	514,000	3,219	4,863	8,082	404.49	2541.48	318.00
TOGO	56,790	56	1,647	1,703	134.45	844.78	201.59
TONGA	748	419	0	419	15.43	96.95	432.17
TRINIDAD AND TOBAGO	5,130	362	0	362	40.41	253.90	142.58
TUNISIA	163,610	1,148	1,424	2,572	228.21	1433.87	179.37
TURKEY	780,580	7,200	2,627	9,827	498.46	3131.95	313.77
TURKMENISTAN	488,100	0	3,736	3,736	394.17	2476.62	150.85
TUVALU	26	24	0	24	2.88	18.08	132.78
UGANDA	236,040	0	2,698	2,698	274.11	1722.26	156.65
UKRAINE	603,700	2,782	4,558	7,340	438.36	2754.33	266.49
UNITED ARAB EMIRATES	75,581	1,318	867	2,185	155.11	974.57	224.20
UNITED KINGDOM	244,820	12,429	360	12,789	279.16	1754.00	729.13
UNITED STATES	9,372,610	19,924	12,248	32,172	1727.25	10852.65	296.44
URUGUAY	176,220	660	1,564	2,224	236.84	1488.10	149.45
UZBEKISTAN	447,400	0	6,221	6,221	377.37	2371.12	262.37
VANUATU	14,760	2,528	0	2,528	68.54	430.67	586.99
VATICAN CITY	0.44	0	3.2	3.2	0.37	2.35	136.09
VENEZUELA	912,050	2,800	4,993	7,793	538.81	3385.44	230.19
VIETNAM	329,560	3,444	3,818	7,262	323.89	2035.04	356.85
WESTERN SAHARA	266,000	1,110	2,046	3,156	290.98	1828.29	172.62
WESTERN SAMOA	2,860	403	0	403	30.17	189.58	212.58
YEMAN	527,970	1,906	1,746	3,652	409.95	2575.79	141.78
ZAIRE	2,345,410	37	10,271	10,308	864.04	5428.94	189.87
ZAMBIA	752,610	0	5,664	5,664	489.45	3075.32	184.18
ZIMBABWE	390,580	0	3,066	3,066	352.60	2215.44	138.39

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TABLE 4 SHAPE INDEX OF SOVEREIGN STATES IN ASCENDING ORDER

STATE NAME	INDEX
SWAZILAND	114.54
MAURITIUS	115.77
ST.VINC/GRENAD.	128.51
LIBYA	130.85
BARBADOS	131.96
MACEDONIA	132.57
TUVALU	132.78
ALGERIA	134.18
VATICAN CITY	136.09
ZIMBABWE	138.39
BHUTAN	139.88
TANZANIA	140.04
EQUATORIAL GUINEA	140.64
YEMAN	141.78
SAN MARINO	142.03
SAUDI ARABIA	142.13
TRINIDAD AND TOBAGO	142.58
NIGER	142.78
SIERRA LEONE	143.24
NIGERIA	143.82
EGYPT	144.86
FR. GUIANA	145.97
BOTSWANA	146.10
SUIRNAME	146.12
KENYA	147.16
LESOTHO	147.19
SRI LANKA	147.58
CHAD	148.57
URUGUAY	149.45
TURKMENISTAN	150.85
GHANA	152.02
SUDAN	152.19
DOMINICA	152.45
LITHUANIA	152.57
RWANDA	155.22
JORDAN	155.36
DJIBOUTI	156.33
UGANDA	156.65
IRAQ	157.41
ROMANIA	158.20
GUINEA-BISSAU	159.41
SYRIA	160.34
MAURITANIA	161.94
MOROCCO	161.98
BURUNDI	164.70
EL SALVADOR	165.70
ANDORRA	166.23
NAMIBIA	167.54
QATAR	167.57
NICARAGUA	167.84
BELIZE	167.92
ANGOLA	171.75
BURKINA FASO	171.96
WESTERN SAHARA	172.62
SLOVAKIA	172.95
IRAN	173.16
PARAGUAY	173.39
LIECHTENSTEIN	173.95
MONACO	173.95
TUNISIA	176.37
BENIN	177.37
GUYANA	177.72
MADAGASCAR	177.76
GUATEMALA	178.41
COTE D'IVOIRE	178.97
ST. LUCIA	179.00
LATVIA	179.28
FINLAND	179.98
ALBANIA	180.01
BOLIVIA	181.48
POLAND	181.87
LIBERIA	182.92
MONGOLIA	182.97
BULGARIA	183.13
MALI	183.49
HUNGARY	183.96
ZAMBIA	184.18
BOSNIA&HERZEGOVINA	184.33
NAURU	184.67
GRENADA	185.11
CENT.AF.REP.	185.96
GABON	187.35
LEBANON	187.82
CZECH REPUBLIC	189.04
GEORGIA	189.23
ZAIRE	189.87
CYPRUS	190.06
SAO TOME AND PRINCIPE	190.29
SOMALIA	190.44
BELARUS	191.81
IRELAND	192.39
SOUTH AFRICA	192.78
AZERBAIJAN	192.97
AFGHANISTAN	193.83
HONDURAS	197.16
LUXEMBOURG	199.15
DOMINICAN REP.	199.74
CAMBODIA	199.89
BRUNEI	201.28
TOGO	201.59
SENEGAL	201.95
KUWAIT	203.50
CAMEROON	204.27
ARMENIA	204.92
KAZAKHSTAN	205.56
ANTIGUA&BARBUDA	205.76
COMOROS	205.89
GUINEA	211.58
OMAN	212.12
WESTERN SAMOA	212.58
SLOVENIA	213.26
MOLDOVA	213.44
BRAZIL	214.48
TAIWAN	215.34
SERBIA & MONTENEGRO	215.59
NETHERLANDS	215.88
SINGAPORE	216.57
GAMBIA, THE	217.61
NEPAL	219.97
MALTA	220.77
MOZAMBIQUE	221.85
UNITED ARAB EMIRATES	224.20
ECUADOR	224.99
ERITREA	225.34
SWEDEN	228.06
VENEZUELA	230.19
PERU	232.76
BELGIUM	234.01
FIJI	235.62
MALAWI	236.11
KOREA (SOUTH)	238.30
COSTA RICA	240.72
FRANCE	241.01
AUSTRIA	243.16
KYRGYZSTAN	245.54
PAKISTAN	246.03
PAPUA NEW GUINEA	247.94
ARGENTINA	248.52
ISRAEL	250.35
SWITZERLAND	257.11
ESTONIA	259.02
AUSTRALIA	262.10
UZBEKISTAN	262.37
UKRAINE	266.49
BURMA(MYANMAR)	267.22
TAJIKISTAN	272.26
SPAIN	272.66
CONGO	273.65
JAMAICA	275.01
MEXICO	278.54
PORTUGAL	279.54
COLUMBIA	280.61
GERMANY	283.79
LAOS	294.66
UNITED STATES	296.44
PANAMA	307.17
TURKEY	313.77
THAILAND	318.00
CUBA	318.90
ST.KITTS & NEVIS	323.19
INDIA	328.32
CHINA	333.67
KOREA (NORTH)	338.65
HAITI	346.47
ITALY	354.40
VIETNAM	356.85
BANGLADESH	358.76
MALAYSIA	360.77
RUSSIA	394.53
CHILE	408.73
ETHIPOIA	420.20
CAPE VERDE	428.81
TONGA	432.17
ICELAND	438.43
DENMARK	468.54
VANUATU	586.99
SEYCHELLES	649.34
UNITED KINGDOM	729.10
MARSHALL ISLANDS	775.81
NEW ZEALAND	823.63
BAHAMAS, THE	846.38
BAHRAIN	884.81
SOLOMON IS.	921.56
CROATIA	927.51
MALDIVES	1048.87
GREECE	1156.07
INDONESIA	1167.07
KIRIBATI	1204.15
NORWAY	1210.81
JAPAN	1365.35
PHILIPPINES	1869.00
CANADA	2256.79
MICRONESIA FED. ST.	6507.43

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EXERCISE

SHAPE INDEX OF STATES

NAME:_____ **DATE:**_____

OBJECTIVE: The objectives of this exercise are to:
a) introduce the student to the concept of shape in geography;
b) to calculate the shape index of a variety of states.
c) to compare the shape index with the actual geometric shape of the state;
d) to produce a written commentary on the importance of shape and compactness in the political geography context.

MATERIALS: a) Area and border data sets for countries of the world.
b) Calculator
c) Conformal maps and tracing paper.

DATA SOURCE: Central Intelligence Agency
World Factbook - 1992
Washington, D.C.; U.S.G.P.O. 405pp.

TIME: Two laboratory sessions (2 hours)

COMMENT:

The geometric shape of a state is often considered, in the context of political geography, as one of the centrifugal and centripetal forces which has an impact on the cohesiveness of the state. In theory, the optimal shape of a state is a circle, thus providing the maximum area in the minimum perimeter. As the shape of the state deviates from this ideal, additional problems may be exposed - such as the addition of diverse physical environments, difficulties of travel and communications, inclusion of additional social groups and similar administrative, social and physical problems. The influence of shape may be decreasing in importance as communications and technology have improved, but with respect to the physical environment, it may be argued that the influence of shape has not declined significantly.

Pounds (N.J.G. Pounds, Political Geography, N.Y.: McGraw Hill Book Co. 1963. p. 46) provides the following table:

INDEX OF COMPACTNESS OF STATES

STATE	LENGTH OF BORDER AS A PERCENT OF THE MINIMUM BOUNDARY
URUGUAY	105
ROMANIA	137
HUNGARY	146
SWITZERLAND	164
BELGIUM	167
MEXICO	258
CHILE	310

EXERCISE:

We shall consider the *shape index* as the length of the actual boundary relative to the length of the of the shortest boundary possible to enclose the actual area of the state.

FORMULAE: Area of a circle: $A = \Pi r^2$ (1)

Circumference of a circle: $C = 2\Pi r$ (2)

Thus: from (1) we determine that $\sqrt{A/\Pi} = r$

and using (2) we calculate $C = 2 \Pi r$

In which:
A = Area of a circle.
C = Circumference of a circle
r = radius of a circle
$\Pi = 3.1415927$

PROCEDURE:
1. Determine the index of compactness of the states.
2. Arrange the states from part one into a list of increasing shape index.
3. Using the tracing paper and your conformal maps; trace the outlines of the most compact, the least compact and two additional states which are intermediate on your list of shape index.
4. Prepare a brief report on the explanation of what you have observed relative to compactness of the states and your conclusions concerning the potential political cohesiveness of the several countries.
5. Turn in this exercise sheet with your written report.

1. DETERMINE THE SHAPE INDEX OF THE FOLLOWING STATES:

STATE	AREA (sq.km) (1000)	r (km)	C (km)	PERIMETER (P) (km)	INDEX (P/C)100
1. AFGHANISTAN					
2. BANGLADESH					
3. CHILI					
4. MONGOLIA					
5. PORTUGAL					
6. LAOS					
7. SWEDEN					
8. FIJI					
9. FRANCE					
10. UNITED STATES					
11. CANADA					
12. PERU					
13. THAILAND					
14. JAPAN					
15. UGANDA					
16. MADAGASCAR					
17. NEW ZEALAND					
18. AUSTRALIA					
19. CHINA					
20. ITALY					

2. REARRANGEMENT OF STATES, BY INCREASING SHAPE INDEX.

	STATE	SHAPE INDEX
1.	_____	_____
2.	_____	_____
3.	_____	_____
4.	_____	_____
5.	_____	_____
6.	_____	_____
7.	_____	_____
8.	_____	_____
9.	_____	_____
10.	_____	_____
11.	_____	_____
12.	_____	_____
13.	_____	_____
14.	_____	_____
15.	_____	_____
16.	_____	_____
17.	_____	_____
18.	_____	_____
19.	_____	_____
20.	_____	_____

3. SHAPE OUTLINES OF THE FOUR STATES.

STATE: _____ SHAPE INDEX: _____

STATE: _____ SHAPE INDEX: _____

STATE: _____ SHAPE INDEX: _____

STATE: _____ SHAPE INDEX: _____